Smart Donations: Event-Driven Conditional Donations Using Smart Contracts On The Blockchain

LUDWIG TROTTER, MIKE HARDING, PETER SHAW, and NIGEL DAVIES, Lancaster University
CHRIS ELSDEN and CHRIS SPEED, University of Edinburgh
JOHN VINES, Northumbria University
AYDIN ABADI, University of Gloucestershire
JOSH HALLWRIGHT, Oxfam Australia, RMIT University

Recent work has questioned the largely unconditional nature of charitable donations and explored the value of conditional giving with contemporary donors. In this paper, we extend this work by exploring how to operationalise features of conditionality in charitable giving, situated in the context of large international non-governmental organisations (NGOs). Building on prior engagements with international aid organisations, we present design considerations and a conceptual architecture supporting real-time, conditional giving for individual and institutional donations. Our architecture leverages properties of distributed-ledger technologies (DLT) to empower donors to (i) attach conditions to their donation, (ii) store funds in a secure, decentralised escrow and (iii) automatically release funds once conditions are met. Unlike prior work that envisions radical disintermediation and the removal of intermediate NGOs using DLT, our work recognises the expertise of NGOs in tackling complex global problems and instead investigates compelling new way for charities to increase transparency and accountability by introducing dynamic pledge controls.

CCS Concepts: • **Social and professional topics** → **Socio-technical systems**; • **Human-centered computing** → Mobile computing; • **Information systems** → *Collaborative and social computing systems and tools.*

Additional Key Words and Phrases: Blockchain, charitable giving, even-driven computing, conditionality

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1 INTRODUCTION

Whether through cash handed to a street fundraiser, or regular electronic bank transfers, charitable giving is typically unconditional, with organisations entrusted to decide how donations are best spent. Charities undertake the complex work of mediating the transfer of aid to beneficiaries, with a simple promise to donors that their gifts, small or large, are managed responsibly and lead to positive social change through aid projects and good causes. However, there are

Authors' addresses: Ludwig Trotter, l.k.trotter@lancaster.ac.uk; Mike Harding, m.harding@lancaster.ac.uk; Peter Shaw, p.shaw@lancaster.ac.uk; Nigel Davies, n.a.davies@lancaster.ac.uk, Lancaster University; Chris Elsden, celsden@ed.ac.uk; Chris Speed, c.speed@ed.ac.uk, University of Edinburgh; John Vines, john.vines@northumbria.ac.uk, Northumbria University; Aydin Abadi, aydinabadi@glos.ac.uk, University of Gloucestershire; Josh Hallwright, joshh@oxfam.org.au, Oxfam Australia, RMIT University.

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new challenges to traditional fundraising channels and models of giving. Trust in non-governmental organisations (NGOs) is on the decline [1, 6], along with the number of individuals giving to intermediaries [2, 6]. Amid increasing competition from online crowdfunding platforms (e.g. 'Gofundme', 'Start Some Good' [13, 41]) and heightened public scrutiny across the charity sector [46, 47], NGOs have come under mounting pressure to demonstrate greater levels of transparency and consider alternative models of giving that can meet the changing needs of contemporary donors. The motivation to address such concerns and a growing popularity blockchain technology [24] has led to recent efforts that aim to utilise distributed ledger capabilities to foster openness, transparency and trust in charitable giving workflows [9–11, 53].

In addition, work by Elsden et al. has explored the value of programmability with donors, by questioning the largely unconditional nature of charitable donations and examined the emerging concept of escrow-based, 'programmable donations' [34], where pledged funds are automatically unlocked and payed-out to selected charitable projects, based on the occurrence of real-world phenomena (e.g. natural disasters or variation in basic food prices). We extend this work by exploring how to operationalise features of conditionality within the 'first-mile' of charitable giving, situated in the context of giving to large international NGOs. We do this by leveraging emerging smart contract and distributed ledger technologies (DLTs) [18] in combination with event-driven computing [49] that allow for flexible, personalised modes of giving that are conditional, self-regulating and enforceable. Informed by co-design activities and an ongoing collaboration with Oxfam Australia and Oxfam GB [34, 42], this approach has the potential to reconfigure donors sense of control and engagement with their pledges, while remaining flexible to the contemporary needs and landscape of international aid distribution.

In this paper, we present two primary contributions. Firstly, we identify domain requirements to support a condition-based donation model between donors and large non-government organisations in the space of international NGOs, characterised through use-case scenarios involving donors and engagement activities with Oxfam Australia and Oxfam GB. Secondly, we outline an architectural approach for supporting condition-based giving with a discussion of emerging challenges in the design of blockchain-enabled capabilities for the charity sector. We believe the provision of dynamic, decentralised and collaborative giving empowers donors to associate more attractive conditions to donations and has the potential to serve as a compelling model to sustain levels of individual charitable giving to NGOs.

2 CHARITABLE GIVING AND DISTRIBUTED LEDGER TECHNOLOGIES

2.1 Motivating Conditional Charitable Giving

Through traditional charitable giving models, donors place trust in the expertise of NGOs and afford them the freedom to utilise resources to deliver positive outcomes for chosen beneficiaries through NGO-led projects. In a systematic review of philanthropic literature, Bekkers and Wiepking identify eight different 'mechanisms' that motivate individuals to give to charity [16]. These range from an awareness of the need to the donors own psychological benefits and the perceived efficiency of the charity. Importantly, this works illustrates the potential need for multiple different fundraising approaches and the ways in which appeals could be personalised to different donors.

NGOs already recognise the need for more compelling fundraising relationships with donors, and increasingly offer restricted fundraising products to address specific challenges or projects. For example, 'Oxfam Unwrapped' [39] allows donors to purchase gift items, such as a goat, or a hygiene kit, via an online catalogue (and in-store cards) for beneficiaries. Oxfam Unwrapped aims to maximise donations by empowering donors to route funds to specific projects. However, Oxfam retains the right to decide how Unwrapped donations are spent and may distribute funds differently if particular gifts are over-subscribed [40]. In addition, the growing popularity of online crowdfunding platforms [13, 41] underlines the willingness of donor behaviours to shift towards services that provide greater choice and a perception of control over direct pledges. However, similar to Oxfam Unwrapped, these services are managed through centralised intermediaries that act as online escrow services controlling the flow of aid between donors and beneficiaries. Moreover, such services do not directly address the problem of control beyond the initial commitment phase or provide any means for donors to stipulate personal conditions as to when funds should initially be released. Therefore, while donors can receive updates on a project's impact, they are powerless in enforcing rules that allow, for example, the reacquisition of funds where intermediary promises are not kept. The concept and architecture we propose in this paper support more tailored experiences of giving, by allowing donors to choose and enforce limited conditions about how and when donations are made. In this paper, we specifically look to extend and operationalise the concept of 'programmable donations', introduced by Elsden et al. [34]. In a co-speculative interview study with everyday charitable donors, the authors explore a range of possible conditions and potential automated triggers to make a donation to certain causes. For example, donors consider giving to a water aid charity each time they visit a swimming pool; or giving to climate change charities whenever record temperatures are reached. The authors highlight how programmable donations could meet the deeply personal motivations that individual donors have for giving to charity, and offer fundamentally new models of philanthropy, with comparisons to forms of insurance or paying taxes. Nonetheless, the authors also present challenges for the implementation of programmable donations, which require careful calibration of contracts and offers made by donors; and be both flexible to donors values, but offer a pre-set and trusted agreement. While aspects of conditional and automated donation services could be delivered in various ways, we focus on how these qualities could be facilitated through DLT.

2.2 DLTs and Charitable Giving

A recent survey of emerging blockchain applications [32] identified a broad typology of their proposed uses. In particular, the survey notes the potential use of blockchains for new forms of currency; crowdfunding and financial services; 'proof-as-a-service'; and new forms of distributed governance. Despite variations of different blockchains (e.g. private, public, permissioned and permissionless), these are potentially attractive features and open a whole range of opportunities for interaction design [37] that allow to reimagine relationships between donor, charity and beneficiaries [25, 26]. Multiple startup companies have begun to leverage blockchain capabilities to promote greater levels of trust and accountability within the charity sector. At their simplest, these projects seek to support more direct forms of peer-to-peer giving – 'BitGive' [7] and 'HelperBit' [11] provide an ability to support the donation of Bitcoin to specific projects and charities. Other platforms such as 'AidChain' [14] or 'GiftCoin' [9] sought to go further in creating their own crypto-token for the nonprofit sector. Running on public blockchains, these projects attempt to mitigate concerns and risks of traditional centralised crowdfunding platforms. Working more closely with existing larger NGOs, 'Disberse' [8] aims to utilise private blockchains to provide a financial infrastructure that overcomes monetary exchange challenges and support cash transfer programming [42]. However, for all these projects, blockchain technologies promise to be able to track donations between accounts and demonstrate greater transparency in the exchange of funds between donors, charities and beneficiaries. Extending this approach are efforts to use smart contracts to create and enforce rules and conditions around the transfer of charitable funds. The ALICE platform [53] and 'Promise' [12] seek to prove and enforce the impact of charitable projects by releasing funds in instalments, as milestones are met. When donating to an ALICE campaign, for example, a receiving organisation can make specific commitments that are later verified by an off-chain, manual impact assessment process. The full funds are released only if the original commitments were met. Immutable smart contracts are required in this case to create and automatically enforce trusted relationships between a network of donors, investors, charities and validators as well as to support the automatic settlement of accounts.

The model outlined in this paper differs in three key ways: In contrast to many of the prior examples that envision radical disintermediation and the removal of intermediate NGOs or charities, our work (i) recognises the invaluable expertise and positive impact NGOs can offer in tackling deeply complex and contested global problems and (ii) considers how technology can empower donors by establishing personal and dynamic rules. Instead of putting a focus on demonstrating end-to-end transparency, we (iii) consider how blockchain technologies, and specifically smart contracts, can be used to reconfigure the dynamic of control between donors and the intermediaries they give to. We, therefore, focus on what we call the 'first mile' of donations (i.e. giving from a donor to a charitable organisation) and enable donors to establish personalised, dynamic rules around the release of their funds, while entrusting the charitable organisations to deliver aid effectively. In particular, we consider the use of smart contracts to support personal and automatically enforced donation agreements between donors and intermediaries, where donations are triggered based on real-world events – for example, a natural disaster, rising food prices, or one's own behaviour.

Event-based, data-driven smart contracts to manage the release of funds are being studied and trialled in other domains. The insurance firm AXA, for example, has trialled Fizzy [43], an insurance product that facilitates the automated pay-out of insurance to air travellers impacted by flight delays using real-time flight data provided by trusted sources. A key benefit of Fizzy to customers is the self-regulation and mitigation of traditional manual claims processes in accessing funds once an event has occurred (i.e. flight delay).

In our work, we extend these use-cases by leveraging novel control dynamics through smart contracts that can self-regulate and automate the release of funds. Thereby, our design not only considers giving through individuals but also supports the establishment of self-regulated, automated contractual agreements issued by institutional donors (i.e. corporations and governments). Unlike existing platforms supporting event-based or data-driven smart contracts [4, 43, 53], our proposed system architecture is highly agnostic and can support a large variety of donors, charitable projects, causes and triggers.

3 PROGRAMMABLE GIVING IN INTERNATIONAL AID

3.1 Conditional, Data-Driven Donations

In this section we first characterise our parametric condition-based giving vision, informed through use-case scenarios in the context of international aid. Secondly, we report early domain requirements of supporting a DLT-provisioned, condition-based donation approach. This work has been shaped through a series of stakeholder engagement activities (i.e. co-design workshops, interviews) with donors [34], NGOs, including Oxfam Australia's 'OxLabs' blockchain innovation group and Oxfam GB's fundraising and innovation teams [36, 42] and domain experts (i.e. consultancy firms, market research, branding and design agencies, blockchain experts) [33]. The engagements are part of an ongoing interdisciplinary collaboration of researchers in the fields of HCI, pervasive systems, international aid and cryptography since 2017. While past research with donors has explored the possible values of programmability to donors[34], in this work we (i) explore programmable giving in the scope of large international NGOs, (ii) outline real-world use cases, and (iii) propose a conceptual architecture to enable the realisation of conditional giving.

We define conditional giving (CG) as the act of committing to donate funds to a charitable organisation with an associated release clause, rule or condition dependent on the occurrence of a measurable event. A donor, for example, may agree to transfer $10 to an NGO-led disaster relief project, each time a cyclone makes landfall on an island in

Oceania. Weather data provided by one or multiple trusted weather agencies act as a trigger that can be used to define a donation condition. In effect, CG enables donors to store funds in a sealed transparent box, with clear rules how much, when and to whom pledges are apportioned. This approach enables donors to enter into explicit condition-based agreements with NGOs.

3.2 Conditional giving for individual donors

Previous work with donors by Elsden et al. [34] has evidenced intrinsic motivators for undertaking programmable giving behaviours. These include donors' willingness to condition pledges related to (i) personal actions, (ii) addressing current needs, (iii) symbolic motives and (iv) activist causes. Building on these findings, we explore the concept of conditional giving situated in the context of international aid. In particular, in this section, we outline three primary application areas for smart donations in the charity sector, developed through early engagements with NGOs and refined during a two-week design engagement (involving interviews and workshops) with Oxfam Australia employees, across different departments (e.g. fundraising, programming, finances). The application areas we discuss below do not represent an exhaustive list of possible uses and applications of Smart Donations. However, they have provided a critical vehicle to discuss its concepts with NGOs and have assisted in developing our broader understanding of crucial domain considerations for the humanitarian sector and subsequent architecture design.

3.2.1 Proactive giving. Currently, emergency appeals are made in response to disasters around the world, such as earthquakes, famine, tsunamis or other destructive events. While aid agencies typically dedicate parts of their funds towards disaster response and prepare in advance to provide a quick initial response, the majority of donations which consequently determines the level of aid, are collected following an event e.g. through emergency appeals. Depending on news cycles, location, time period, frequency and various other factors, different disaster relief efforts elicit various levels of public support which consequently determines the level of aid the organisations can provide. This reactive model of giving currently executed

causes delays for effective aid to be provided and further imposes financial risks for aid organisations when pre-funding public appeals. A proactive model for giving as outlined in this paper would allow charities to better optimise their response, based on the donations they know they will receive in case of an emergency. A donor could sign an agreement to 'become a lifesaver' and commit a one-off or dynamic donation that will be disbursed to a disaster emergency response in the event of a disaster. The events can be verified by international, cross-agency efforts such as the Global Disaster Alert and Coordination System (GDACS) [28] or the Global Seismographic Network [19] to effectively validate events and trigger the release of funds.

3.2.2 Dynamically Giving to Ongoing Programs. There are many projects for which a charity's work is vast and ongoing, for example, fighting climate change or improving women's rights. Such ongoing issues can be brought into focus by events in the world, or one's personal life. We propose to use Smart Donations to link regular, incremental support for these important issues, to such events. For example, a donor may set up a contract to make a small donation to a climate change project, every time air pollution crosses a certain threshold in Sydney or Mumbai during the summer. Charities and agencies monitoring air pollution could collaborate to validate such a condition. Up to a limit, the value of the donation could be proportional to the level or extremity of a specified phenomenon. The aim here is to create a link between real-world phenomena, and a wider issue the donor supports. As such, the experience of giving could become more responsive and dynamic.

3.2.3 *Giving through personal behaviours.*

Besides providing financial support through monetary donations, contemporary donors which NGOs have also described as ‘globally engaged citizens’ [34] want to live their lives with greater social responsibility. For example, a donor might aim to reduce their CO2 footprint, waste less water or spend less money on alcohol. Co-creative workshops and interviews with potential donors [34] indicated that personal behaviours linked to an NGO cause could provide novel, yet playful models to give to charity, building on positive and negative reinforcement. In some cases, such as using public transport or flying, it may be possible to leverage existing data from transport companies and airlines and donate based on saved CO2 when using public transport, or to offset a flight. Furthermore, financial data (i.e. credit card or banking information), sensors and other personal informatics could be used to provide additional data to verify certain behaviours. In some cases, we might even trust the donor to ’self-validate’ and admit to their own actions when prompted, or consider a donor’s social contacts as validators. For example, one may nominate a partner, flatmate, or trusted friend(s) to affirm a condition.

3.3 Institutional giving

Workshops and interviews with NGOs and domain experts highlighted the importance of ’institutional giving’, that refers to funding through organisations, usually government bodies, intergovernmental organisations or corporates. Institutional donors usually operate within long approval and funding cycles as well as strict organisational policy frameworks. However, especially in the context of disaster-relief, NGOs and charities are relying on a timely release and distribution of funds provided by institutional donors. Unlike existing platforms [10, 11, 53] and current work [34] which is largely focusing on giving through individual donors, we argue that self-regulated and automated conditional giving is ideally suited to facilitate charitable funding through institutional stakeholders. By using escrow-based, event-driven and automatically enforceable agreements, institutional donors are able to create comprehensible, transparent funding pools that reflect their specific mandates and operate within their organisational policy frameworks and funding cycles. A governmental organisation, for example, the Australian Department of Foreign Affairs and Trade (DFAT), could provide a two-year funding pot for disaster relief activities for endangered islands in Oceania, that is validated by GDACS. By creating a ’Smart Donation’, DFAT would have to define a set of specific, quantifiable conditions (i.e. earthquake, tsunami, volcanic eruption, cyclone) that can trigger a financial response to a specific NGO, while the issued amount may be dynamically associated with the event, e.g. the severity of the eruption, or the number of people affected. Leveraging the decentralised approach of DLT, in combination with event-driven computing and relying on quantitative data, the verification and enforcement of the aid response can be clear, comprehensible and detached from any potential external bias. A programmatically enforced release of funds does not rely on the interpretation and approval of stakeholders, hence has the potential to significantly accelerate the release and distribution of funds. Similar to the proactive giving model for individual donors outlined earlier, the use of Smart Donations would enable NGOs to better optimise their response, as available resources have been agreed on in advance. We further argue that the decentralised accountability of funding pools that originates in the underlying properties of DLT could furthermore promote increased transparency within the aid sector.

3.4 Domain considerations

In this section, we outline emerging stakeholder (i.e. NGO & donor) considerations to support the future development and adoption of a condition-based donation model. Moreover, we emphasise that while the realisation of a condition-based donation model is possible without DLT, as is the case with traditional bank remittance services, the changing needs of donors and NGOs can be more effectively addressed by leveraging DLT functions (i.e. enforceable agreements) and emergent properties (e.g. immutability, trust) to better manage the complex control dynamics of conditional donations.

3.4.1 Verification of real-world phenomena. Verification of real-world phenomena is essential to the operation of the types of conditional use-cases outlined. Both donors and NGOs require reliable, scalable means to confirm real-world events and to validate conditions before agreements can be constructed. While donors are not necessarily concerned with the underlying method of event verification (e.g. third-party data providers, crowd-sourced from social networks), understanding the trustworthiness of the data that describes external phenomena is critical to ensure future adoption. While mechanisms that aim to demonstrate trust in data providers have been widely researched [17], conditional Smart Donations raise new requirements and expectations on the availability of data from third parties. For example, Smart Donations impose the need for capabilities that provide donors with confidence that data used to perform the verification of conditions is and will stay reliable and trustworthy over the period of the established agreement. The dependency on the availability of particular data to unlock funds further highlights the need for mitigation strategies (e.g. the cancellation of the agreement, the replacement of the data-provider or redundancy of data-sources) which would need to be in place prior to a donor's commitment. In addition, a trusted architecture must provide robust means to ensure the integrity of data vendors and mitigate against external influences through financial or political motives.

3.4.2 Stakeholder feedback & donation reporting. Traditional approaches to giving afford donors feedback in various forms including physical acknowledgement of a gift, monthly subscription statements, or periodic impact reports. In contrast, the longitudinal nature of a conditional giving model, driven by real-time events, would place new demands on NGOs to report the status of pledge agreements such as the transfer of funds triggered by a particular event or behaviour. Limited donor awareness of on-going agreement conditions and sudden unexpected fund transfers could raise reputational concerns for NGOs. Therefore, the ability to notify stakeholders as part of an active donation agreement about changes in real-time events, conditions and triggered actions appears to be essential. In addition, transparent stakeholder feedback and reporting may be able to further elevate trust in the system and could be used to demonstrate the impact of a donor's contribution. Initial discussions with donors and domain experts suggest that transparent donation reporting could further motivate donors to renew their offer and thus contribute to an increase in donations.

3.4.3 Enforceable multi-party donation agreements. The notion of a 'long living', event-driven donation raises a number of practical governance concerns for NGOs. Clause dependent donations introduce a more complex model for both donors and NGOs that require cost-effective, real-time, enforceable agreements to enable the secure exchange of funds at scale. Current bank escrow services act as trusted third parties to facilitate similar exchanges of funds between parties based on pre-agreed conditions. However, due to the manually intensive process of enforcement, and need for notary banking operatives to verify conditions have been met, traditional banking services are not well-suited to meet the needs of a dynamic donor-NGO relationship.

3.4.4 Secure and stable exchange of digital assets between stakeholders. The execution of conditional pledges requires the exchange of funds between donors and NGOs that is both timely (e.g. for disaster relief) - where the movement of funds can be facilitated in response to real-time processes, and in a flexible manner, to allow individual donors to agree on different rules that define when and how much of a donation can be received by a beneficiary. In the context of charitable donations, such an exchange of digital funds should also be clearly auditable by a regulator and in accordance with local regulations. At present, existing banking transactions are constrained both in terms of timeliness and flexibility. International bank transactions, for the SWIFT network, for example, must be validated by a third party and typically take days to settle, with traditional fiat transactions dependent on banks to verify their authenticity based on constrained transaction conditions. The emergence of cryptocurrencies has the potential to address issues of timeliness and flexibility through real-time self-validation of transactions, and the ability to define unbounded rules for value exchange. However, beyond the lack of an in-depth of understanding of how cryptocurrencies operate within the charity sector, the economic volatility of digital assets underlines the need for NGOs to support mechanisms that offset the potential loss of value through exchanges between digital assets and fiat money.

3.4.5 Support for configurable causes & conditions. Large NGOs, such as Oxfam, can have legitimate concerns about disintermediation through the reconfiguration of control over the apportion of donations. Providing a balance between the influence of donors and NGO expertise to inform decision-making is critical for the future acceptance of Smart Donations through donors and NGOs. Maintaining a level of authority over the types of conditional giving models donors can choose appears to be critical for charities to prevent a fragmentation of funding and to archive a 'critical mass' to provide aid, while donors suggested that the provision of a broad range of customisable donation agreements is of high importance. Scoping donations to particular causes of interest has already been exercised in the past (e.g. Oxfam Unwrapped). While Unwrapped options are relatively simple to configure, the use of conditional donation models requires capabilities for NGOs to establish complex agreements that integrate third-party data providers and a broad range of configurable condition triggers. However, unlike Unwrapped gifts which are linked to finite needs, Smart Donations are capable of supporting much broader funding budgets. These broader budges not only afford the charity more flexibility on the ground but are less exposed to over-funding. To mediate the funding amounts, the platform may support minimum and maximum funding amounts, or integrate funding targets/milestones at which point campaigns could wound down.

3.4.6 Identification & privacy of stakeholders. The discussed use-case scenarios in section 3.2 and section 3.3 highlight the complexity of stakeholder roles and responsibilities involved in the process of data-driven conditional giving. Comprising of donors, beneficiaries, data-providers and NGOs, the presented donation model imposes challenges related to identification and privacy of stakeholders. Increased transparency, in particular through the use of distributed ledger technology, where information is immutably stored and accessible across multiple nodes requires a comprehensive assessment and additional care when designing and implementing Smart Donations. Donations triggered by personal behaviour, for example, may expose privacy-related data of individual donors. In addition, third party access to distributed data sets could lead to unintended exposure of staff, partners and beneficiaries, which could affect their safety and the successful implementation of humanitarian operations, especially in unstable crisis regions. Thereby, it should be considered that not only payload data, but also the exploitation and analysis of transactional meta-data may accidentally reveal privacy sensitive information [27]. While the increasing demand for transparency and the personal rights and security of donors, staff and beneficiaries may seem conflicting, the architectural approach (outlined in section 4) aims to resolve this conflict between open accountability and the need for privacy and security of the parties involved, by mediating access to critical data.

3.4.7 Stakeholder interactions and intermediation. Many of the upcoming giving platforms, especially in the field of blockchain technology, promote the disintermediation of giving, by connecting potential donors with projects and individuals in need. Very often, intermediation is seen to be one of the main obstacle and a drawback for the contemporary delivery of aid, for example, through the introduction of additional fees, by promoting corruption, complex organisational structures or by delaying the delivery of aid.

Although these may be legitimate concerns, a one-sided evaluation neglects the important role NGOs play in the effective delivery of aid. Apart from pooling donations to deliver larger projects, they provide expertise and manpower, for example, to provide effective and timely disaster relief, give a voice to underrepresented groups, spark social discourses and help to shape policies and political decisions. More importantly, by serving as trusted and secure intermediaries, NGOs protect all parties involved, for example, by vetting local partners and the legitimacy of projects to protect donors from corruption. Likewise, volunteers working for charities go through a comprehensive screening process and background checks through governmental official and NGOs before being in contact with vulnerable individuals. Direct donor to beneficiary relationships could expose donors to potential scam through fraudulent stakeholder or promote power imbalances between the financially strong and weak, hence, facilitate the exploitation of people in need. Through careful consideration and balance between inter- and disintermediation, we believe that future non-profit DLT platforms will be able to support well-established operational mechanisms of international NGOs, mitigate against the introduced risks and effectively address the issues and criticisms raised.

3.4.8 Mitigation of abuse. Due to their apparent anonymity, blockchain-based cryptocurrencies have quickly attracted the attention of criminals and were soon adopted. Today, cryptocurrencies serve as a convenient means of payment in illegal "underground markets", for example, to purchase drugs and arms, facilitate human trafficking and sexual exploitation, and is used to freely move illegal financial assets or to launder money [22, 50, 59]. Through the introduction of a legitimate, secure and stable exchange of digital assets and fiat money, an altruistic platform run by NGOs could unintentionally be misappropriated as a tool for criminals. While speculative, such abuse would not only contradict the fundamental principles and mission of the charitable organisations but may also negatively impact on an NGOs reputation and could impose legal consequences. Hence, organisational and conceptual mitigation strategies must be carefully considered when adopting programmable giving approaches.

4 CONCEPTUAL ARCHITECTURE

In this section, we present our architectural approach and discuss the underlying model. This reference architecture supports event-driven parametric donations to facilitate the establishment of enforceable agreements between donors and NGOs. Our architecture builds on prior engagements with NGOs, domain experts and donors [33, 34, 36, 42] and addresses emerging domain considerations, challenges and risks discussed in section 3.4.

Our proposed architecture allows (i) a single or group of NGOs to create donation templates (i.e. funding themes or funding pools) that enable (ii) donors to choose, configure and personalise donations from a predefined set of conditions and triggers. A (iii) value exchange mechanism supports the conversion of fiat currency into digital assets that (iv) can be attached to a donation. Digital funds are (v) held in a secure, transparent and immutable on-chain trust fund, that we refer to as escrow. Funds are (vi) programmatically transferred to the beneficiary as soon as the conditions specified by the donor have been met. Our architecture allows (vii) real-time data qualification of conditions based on (viii) quantifiable data, provided by trusted external data-providers or public data-sources.

4.1 User roles

In section 3.4 we introduced the stakeholder relationships and highlighted potential conflicts between NGOs (trustees), donors, beneficiaries and external data-providers. Here, we specify key stakeholder roles and a permission model, that is sufficient to mediate interactions between stakeholders and attempts to mitigate against systemic abuse.

4.1.1 Trustees. Verified NGOs act as decentralised trustees. Organisational or structural changes within the network (e.g. enrolling new NGOs, withdrawing a Smart Donation template, issuing donations) are resolved using established DLT voting procedures, with each trustee having an equal number of votes. Trustees also manage off-chain infrastructure, for example, databases and money exchange platforms. In addition, only trustees are able to issue Smart Donation templates, which contain a set of basic properties, for example, the duration of a contract, possible conditions, validators and a set of beneficiaries.

4.1.2 Donor. Regular users, whether individuals or organisations, enrolling to the platform are assigned the donor role. Upon registration, donors are able to exchange fiat money to digital assets, can browse for a template, select, configure and sign Smart Donations, which seals their funds in the on-chain escrow and receive notifications about their current donations. Donors cannot directly interact (i.e. send funds) to other stakeholders.

4.1.3 Beneficiary. Our architecture supports donations to individuals, organisations, charitable projects and funding pools. Upon review and approval through the trustees, beneficiary accounts can be assigned to specific donation templates. Beneficiary accounts are the only account type to which an escrow can disburse raised funds. Fiat withdrawals can only be made to a preconfigured bank accounts and are subject to approval through the trustees. A beneficiary cannot send funds to other stakeholders, or pledge funds in Smart Donations.

4.1.4 Data-provider. In the presented conditional donation model, trusted data-providers and external data-sources play an important role in the verification process of particular events that lead to the fulfilment of donor defined conditions. As for the enrolment of beneficiaries, third party data-providers are subject to a comprehensive vetting process and need to be approved by trustees. To prevent potential abuse, data-providers cannot hold digital assets.

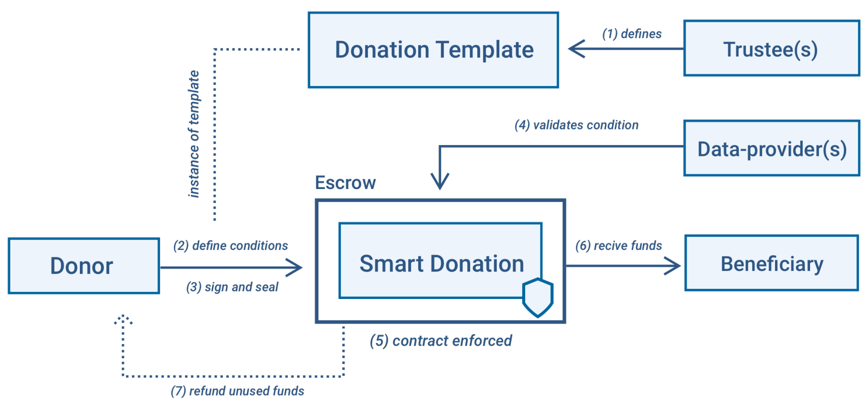

Fig. 1. Interaction flow diagram for the setup, configuration and validation of a Smart Donation.

4.2 Interaction flow

The flow diagram (figure 1) provides an overview of the interplay between each stakeholder. As trustee(s), NGOs are able to (i) issue donation templates that define the basic parameters (i.e. the scope of available conditions, minimal and maximal duration and validators), suitable for the affiliated project or funding pool. Donors are able to (ii) personalise a donation by configuring instances of the donation templates (e.g. assign the duration, the amount and their particular conditions). Once signed (iii) funds are sealed in an escrow that neither the donor nor the charity can access. Smart donations (iv) verified by a data-validator or external data-source (v) are programmatically enforced and (vi) funds are transferred to the corresponding NGO project or beneficiary. Remaining funds that have not been issued are (vii) returned to the donor.

The presented conceptual architecture employs a strict role and privilege model as well as rigorous intermediation of the flow of money through smart contract escrows, which we believe, is able to significantly reduce the risk of misuse and fraudulent activities. By preventing a direct donor and beneficiary interaction, we circumvent potential issues around power imbalances discussed in section 3.4.7. In addition, the imposed vetting mechanism of beneficiaries and validators aims to mitigate the risk of fraud through scammers. Through the limitation of a free circulation of crypto assets within the network, we further prevent potential misappropriation for illegal activities (see section 3.4.8).

4.3 Architectural design

Literature has identified limitations of blockchain technology regarding scalability, e.g. limited transaction throughput, computational costs and high storage demands [30, 52, 62]. In addition, prior engagements discussed in section 3.4.7 have raised concerns regarding stakeholder privacy and safety. These considerations have led to a hybrid design (see figure 2) that keeps certain components off-chain. The proposed conceptual architecture comprises three layers: (i) A smart contract compatible blockchain, (ii) off-chain components and (iii) a visualisation layer. The architecture aims to combine the performance, efficiency and leverage existing legal frameworks of conventional computer systems without compromising on the advantages of blockchain technology, in particular, transparency, self-regulation and security.

The blockchain provides the run-time environment for smart contracts that contain the business logic for the value exchange and escrow. The off-chain systems are distributed between participating NGOs and third-party service providers.

Critical user data of donors and beneficiaries are hosted in the secure local environment of NGOs. To further optimise storage costs in our reference architecture, NGOs are required to store all data related to their smart contract templates and link these to the blockchain smart contracts. Specific modules for user management further allows individual charities to connect their customised user interfaces (apps or web apps) with the Smart Donation network. Depending on the use-cases and their technical capabilities, NGOs may also provide utility modules, such as scheduling services and data-provisioning gateways, that we will describe more in-depth in section 4.5. Components that will be hosted externally are in particular cross-NGO currency exchange platforms, cloud messaging modules used for push notification services on the mobile apps (i.e. Google Cloud Messaging) and validation modules of third-party data providers. The visualisation layer provides management interfaces NGOs, a dashboard for beneficiaries and a mobile application for donors. All off-chain components expose REST-API endpoints that allow for easy integration with various services, modules and clients. The off-chain systems and the visualisation components are connected to the blockchain through a middleware.

4.4 Blockchain and Smart Contracts

Our proposed architecture design is, apart from the requirement for a smart contract runtime environment, agnostic to specific blockchain implementations and supports public and private networks. To evaluate the feasibility of our proposed design, we specifically considered it's operationalisation on a private, permissionless Ethereum instance. Ethereum provides a cryptographically sound, decentralised, tamper-proof protocol and features support for smart contracts [18, 61]. Smart contracts are computing protocols that execute rules and enforce agreements without the

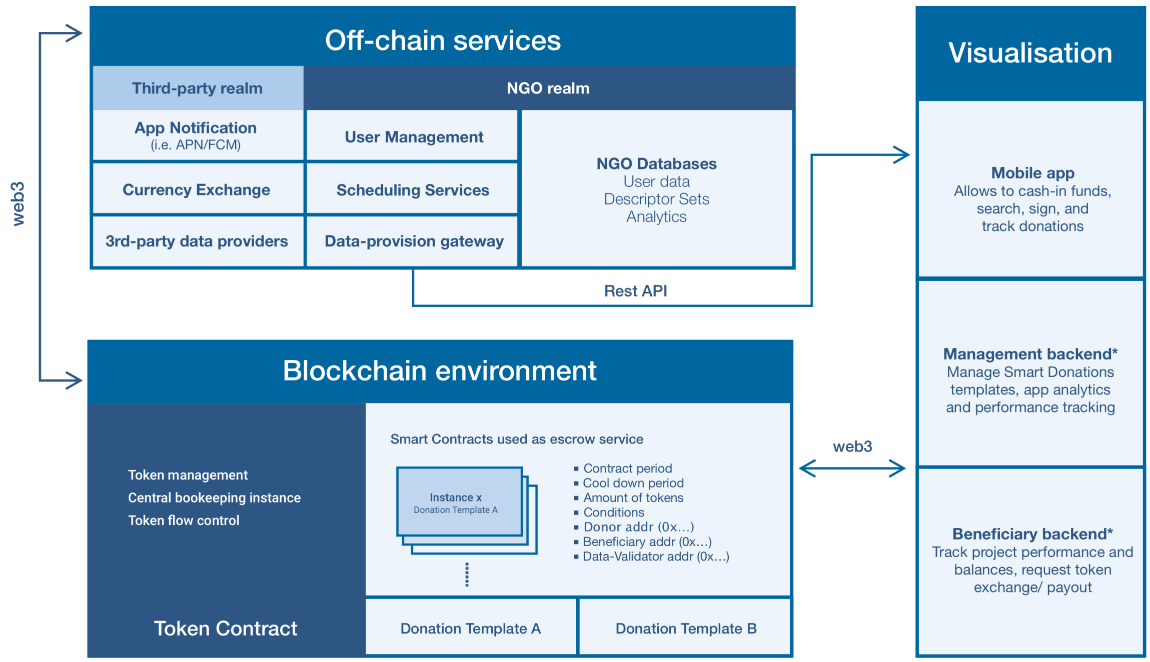

Fig. 2. High-level architecture concept

need for intermediaries [18]. Our Smart Donations model utilises these properties to programmatically enforce the transfer of digital assets. To facilitate the transfer of digital assets, a *token contract* serves as a central bookkeeping service that is linked with the actual *donation contracts* which govern the rules and conditions of donations. Each Smart Donation template is underwritten by a single donation contract.

4.4.1 Token Contract. The *token contract* is used to govern the exchange, creation and transactions of digital assets between stakeholders within the network. The token contract has an embedded role and privilege model that governs the flow of tokens and prevents, for example, direct transfers between donors. To ensure interoperability with other blockchain-enabled applications (e.g. wallets), the token contract is compatible with the ERC-20 token standard [60]. Serving as the central bookkeeper, the token contract stores records of all account balances and transactions and is the gateway interface between the ledger and the fiat money banking system.

4.4.2 Donation Contract Template. The *Smart Donation contract templates* provide the general terms and a set of available conditions. It defines, for example, the minimal and maximal duration for an offer, the expiration date of the template, the minimum and maximum amount that can be pledged. The template also includes a pointer to a set of conditions donors can choose from, the blockchain addresses of the trustee that created the template, as well as assigned beneficiaries and data-providers. The descriptive information such as title, description and images are stored off-chain and are linked to the individual template. The verification process and the release of funds for each pledge is part of the business logic embedded in the Smart Donation template contract.

As part of our design process, we have evaluated different approaches and mechanisms to seal the donors' commitments in the smart contracts: Model i) stores each donation in a single smart contract (one to one relationship), model ii) attaches multiple donations to a single smart contract (many to many relationship), and iii) is based on one overarching smart contract that supports multiple projects and can be underwritten by multiple donors (one to many relationship). While i) provided a very high level of flexibility, creating individual smart contracts for every donation would significantly increase costs and impact on performance and scalability as transactions. The validation of a single earthquake, for example, would be the multiplication of the number of pledges. Model iii) is the most cost-effective model, however, the differences between campaigns and requirements that could change over time raised concerns regarding update capabilities, increased complexity of such a smart contract and its generalisability. After an in-depth evaluation, we argue that ii) offers an optimal balance between performance and flexibility, as it allows to verify multiple pledges with a single transaction while providing sufficient flexibility for varying projects and future changes.

4.5 Off-chain components

This section provides an overview of the off-chain system components, implemented following a traditional server-client model. By employing a hybrid approach, we aim to reduce storage costs, address stakeholder privacy and data protection laws, mitigate performance issues and provide additional functionality (i.e. scheduling) that is not currently supported by the underlying Ethereum platform.

4.5.1 Off-chain storage. Project-related data, such as descriptions, images and additional reports, that may be used to provide contextual information about causes to end-users, are stored in traditional relational databases. This minimises storage expenses and reduces transactions on the blockchain. Besides a blockchain account comprising of a public private-key pair, donors hold an off-chain user account for mobile or web applications. In accordance with data protection laws, sensitive personal information of beneficiaries (e.g. bank information) and donors (e.g. email address) are stored on access restricted relational databases. We are able to prove the integrity of data that is stored off-chain, by providing a mechanism to proof off-chain information (i.e. using hashes).

4.5.2 Utility modules and third-party plugins. Blockchain technology is still in their infancy and lacks specific functionality that facilitates a widespread adoption. For example, Ethereum does not offer scheduling functionalities to invoke functions on a smart contract based on date and time or block number. Our system supports time-dependent functionalities e.g. the automated refund of expired donations through the use of an off-chain scheduling module that regularly pushes the current date and time to the blockchain. Off-chain notification modules, that monitor the donation contracts, are used to inform donors and beneficiaries about changes. To facilitate data-validation for services and third-parties that cannot directly interact with the ledger, we introduced data provisioning gateways, that provide a traditional HTTP REST API endpoint. During the workshops, participants envisioned a diverse set of Smart Donations. Some relied on active user input through a customised user interface (e.g. to enter data) or additional program logic (e.g. validation through a fitness tracker). We account for this by allowing the integration of third-party plugins that can provide additional business logic as well as a user interface through a web view.

4.5.3 Currency Exchange. Smart contract escrows are only able to store digital assets like cryptocurrencies or crypto tokens. Hence donors have to exchange fiat money before creating a pledge. However, volatility in the cryptocurrency market presents a significant obstacle for NGOs in adopting DLT. Our conceptional design of a trusted exchange mechanism aims to address these concerns by relying on a secure and price-stable ERC-20 token. Using common payment methods such as credit cards, direct debit or prepaid cards, our presented exchange mechanism allows the conversion of fiat money into digital tokens to a fixed exchange rate that is tied to a reference currency (e.g. USD, EUR or GBP). All fiat currency transactions are processed by a trusted payment service provider (e.g. a bank, a fintech service or an NGO), that connects to the blockchain through the dedicated payment gateway. All transactions are governed by the token contract, which mitigates double-spend attacks and prevents in- and deflation on the network, by ensuring that the token supply is matching the fiat currency reserve holdings.

5 DISCUSSION

In this paper, we have begun to explore an innovative model towards charitable giving that introduces novel donation control dynamics between donors and NGOs using decentralised ledger technology and smart contracts. Our work presented motivating use-cases, highlighted important domain requirements and outlined a conceptual architecture to support their implementation. This discussion aims to reflect on emerging requirements, challenges and opportunities in designing DLT for conditional giving, emphasising the need for further research into the application of DLTs in charitable giving.

5.1 Responsible data and DLTs

The international development sector is beginning to recognise the important role of "responsible data" [3, 54]. Amid a growing awareness, blockchain technology and its opposing promise of radical transparency is disrupting the sector. While DLTs have proven to be a well-suited technology, e.g. to govern and trace the flow of digital assets, we highlighted a set of challenges related to stakeholder privacy, which especially in the domain of international aid can correspond to concerns over personal safety, for example, by sparking discrimination and violence. In addition, the adoption of DLT raises more practical challenges around its compatibility with existing legal frameworks and regulations, such as the European General Data Protection Regulation and its' right to be forgotten', that seems to be incompatible with immutable decentralised storage. [48] Our outlined architecture aims to overcome this conflict by introducing a hybrid approach, where personal donor data is only stored on the NGO's existing database infrastructure. Our approach thereby leverages the extensive expertise and understanding NGOs have built up to manage sensitive personal data of donors and beneficiaries in the past. We argue that this approach is suitable to store sensitive personal data responsibly, secure and legally compliant.

5.2 Trusted and reliable event-validation

Our vision of conditional giving is founded on the quantifiable expression and verification of real-world events. We argue, that simple and clearly defined rules and triggers will help individual and institutional donors to better express and understand for what cause, when and how they donate to charity. However, programmable giving requires donors confidence in the reliability, fidelity and appropriateness [34] of the data that underwrites the validation of expressed conditions. Releasing funds incorrectly would not only result in loss of confidence but could, for example, impact on the effectiveness of disaster response. This dependency on data raises questions around how we should define and verify data-sets, how we can ensure its availability and how it affects donors trust. Hence, it is important to recognise the crucial role that a data provider or validator plays in the system.

DLT and smart contracts have proven to be an effective technology to define, validate and enforce rules to govern and record the transfer of digital assets. However, the ledger has no reference to the real world, hence, relies on external trustworthy third-parties, called 'oracles' to provide the data. While blockchains have introduced robust solutions to maintain data integrity on the chain, it is highly depended on the integrity and correctness of external data, which literature often describes as the "garbage-in-garbage-out" (GIGO) dilemma [15, 58]. A plethora of technology-driven projects, for example, chainlink [31] or proveit [45], to name a few, explore interesting technical solutions to verify data integrity and availability between APIs and the blockchain. However, while technological solutions progress, there is still a gap in understanding critical human factors, for instance, the conflicts between automatisation and oversight of validations, opportunities for civic engagement and altruistic models to replace money-driven incentivisation approaches and to ensure the provision of 'good' data.

5.3 Crypto-assets and exchange

The exchange of fiat money to digital assets is necessary to leverage the self-governing functionalities that underpin smart contracts on the blockchain. However, the exchange of funds, in particular, presents challenges concerning accountability and liability, creating a barrier for charities and NGOs to adopt blockchain technology. NGOs manage funds provided by individuals, institutions as well as governments and, for example, issue receipts for donations that can have tax implications. Therefore, they not only carry a moral responsibility to manage and use funds responsibly but are further subject to strict regulations and compliance audits. These considerations have shaped our design, in particular, the type of crypto-assets, as well as the exchange mechanisms we used. Owing to the significant volatility, popular cryptocurrencies like Bitcoin or Ethereum [20, 38] have shown to be unsuitable for the charitable sector. So-called 'stable coins' aim to overcome price volatility by either backing its value with collateral (e.g. MakerDAO) or tying its value to currencies (e.g. Tether or Binance USD). However, like regular cryptocurrencies, they are subject to legal regulations, including absolute or implicit bans in some areas [5]. Especially in international aid and development, this has a significant impact on the flexibility and legal compliance of the respective NGOs. Through the adoption of public crypto-assets, NGOs would further relinquish a central part of their control (e.g. on the flow of tokens) to unknown stakeholders.

Therefore, our architecture proposes the use of utility tokens for a distributed book-keeping service, that we believe will not be affected through the before mentioned crypto-regulations. The use of value exchanges governed by NGOs themselves as 'gate-keeper', may strengthen accountability and reduce exposure to risks, e.g. prevent the misuse through criminals under the disguise of a reputable NGO. Embedding the exchange mechanism in the existing ecosystem of charities could further reduce entry barriers for donors, for example, by allowing the purchase tokens as vouchers in charity shops, instead of exchanging tokens at third-party or decentralised exchanges.

5.4 Security considerations

Like no other current technology, DLT has built up a strong reputation in regards to security, transparency and trust. A recent study conducted by Deloitte, [29] reported that 71% of enterprise organisations believe that DLT provides a greater level of security than traditional IT. While DLT, underpinned by cryptographic algorithms and through its distributed approach has some advantages compared to traditional systems, several attacks on blockchain networks [56, 57] and reports describing vulnerabilities of smart contracts [51] demonstrate its limitations. While an in-depth evaluation of blockchain risks and vulnerabilities are beyond the scope of this paper, we argue that the operationalisation of DLT in organisations requires a thoughtful assessment as the hype around the technology could easily lead to a deceptive perception of security. Besides technical vulnerabilities, for example, during the design and development of smart contracts, NGOs need to implement organisational strategies and directives, e.g. to manage crypto-assets and access keys. As discussed earlier (see section 3.4.7 and 3.4.8), we further argue to consider external factors like risks for misappropriation and fraud, which often seem to be neglected.

5.5 The right blockchain: Public, private, altruistic?

Prior work underlines the importance of transparency [44] and trust [1, 6] within the charity sector. And indeed, enhancing trust through increased civic engagement [23] and governance, transparency, as well as accountability [26], are central motivators for the use of DLT in the contexts of charitable giving [21, 24, 42]. Therefore, one may argue the implementation of blockchains for NGOs on a public ledger would be a logical consequence since public ledger would allow everyone to validate the integrity of transactions.

However, besides questions regarding 'responsible data' (see section 5.1), further technical and conceptual limitations discourage the use of public ledgers in the charitable space. An important concern relates to resource and energy efficiency of public DLTs. Most of the public ledgers employ proof of work consensus models, which are known to be energy-intensive and therefore contradicts principles of sustainability many NGOs aim to adhere to [55]. And even if long-promised alternative consensus models like proof-of-stake, that have the potential to reduce energy costs, are eventually adopted more broadly, duplication and networking costs may never match the efficiency of regular databases. Another issue is founded in the incentivisation model underpinning public blockchain verification processes (mining) that builds on monetary awards for stakeholders. This leads to undesirable costs for stakeholders but moreover questions its conceptual feasibility. As the transaction throughput of DLTs is limited and transaction costs are mainly driven by demand (i.e. the number of concurrent transactions), a successful campaign could lead to a temporary increase in fees. Peaks in Bitcoin that have already temporarily exceed the £20 median monthly donation of UK donors [6], illustrating the significance of this issue. While our conceptual architecture aims to reduce transaction and storage costs e.g. by pooling validations or offloading data to off-chain services, this correlation raises serious questions on the viability of utilising public ledgers. Private ledgers on the other side would allow for more efficient consensus models like proof-of-authority, hence mitigates issues around storage and energy consumption. While private networks are well suited for testing concepts and piloting the technology, they fall short regarding the promise of transparency and increased civic engagement. Moreover, if governed by a single entity or a small group with unbalanced power relationships, private ledger can quickly be degraded to nothing more than an inefficient, restricted database.

A reflective discussion of the advantages and drawbacks of the various DLTs raises questions around the design of an altruistic blockchain. We would like to stipulate an open discourse, challenge current trade-offs between governance and transparency and encourage the exploration of alternative approaches, considering domain requirements like sustainability, accountability, control and trust. We believe that a blockchain network driven by altruistic, rather than financial motives, could be the first step towards broad adoption of DLT in the charitable sector. However, its design requires a better understanding of control dynamics, for example, to enable distributed governance for registered institutional stakeholders, while providing means of civic accountability.

6 CONCLUSION

In this paper, we report on early design considerations for an event-driven, condition-based model to support individual and institutional monetary giving to charitable organisations in the context of international aid. Moreover, we describe a conceptual approach and reference architecture that leverages emerging DLT and event-driven computing to address shortcomings in traditional forms of giving and support for more compelling relationships between donors and intermediaries. Informed through early engagements with NGOs, we discuss challenges of supporting a DLT-driven donation model within the charity sector, including issues of digital asset volatility, verification of real-world events and trade-offs between public and private blockchains. More critically, we aim to stress the crucial role intermediaries play and argue that while the use of distributed ledgers in the charity sector primarily proposes to bypass the need for intermediaries, blockchain should be re-purposed to enhance NGO relationships with contemporary donors through enforceable, trustworthy giving agreements.

7 FUTURE WORK

We seek to promote continuous research in the mechanics of DLT-supported programmable giving through the release of a reference implementation of Smart Donations platform and mobile app. Facilitated through a series of longitudinal studies, our future work will focus on the refinement and evaluation of the underlying concept and architecture. In particular, we plan to explore donor expectations, attitudes and preferences by developing and testing a range of content and possible uses of Smart Donations utilising multiple data-sources, causes and conditions. As part of a comprehensive risk assessment, we further indent to explore potential risks of unintended consequences, extending our critical, yet speculative reflections [35] of the Smart Donations platform. We have further started with the design of a version of Smart Donations building on conventional computing approach. We plan to conduct a study comparing cost, performance, privacy and security of operating DLT-based decentralised solutions with those following a centralised approach. Our initial pilot of the Smart Donations platform and the comparative study will be conducted with Oxfam Australia, operating as the sole trustee. However, we are interested in conducting subsequent studies with multiple trustees that aim to explore the dynamics, potential conflicts and synergies as well as specific technical and socio-technical challenges, for example, voting mechanisms to resolve conflicts, of our proposed architecture. By continuing our ongoing collaboration and engagements with international NGOs, domain experts and donors, we more broadly aim to address emerging requirements, challenges and opportunities for operationalising DLT in the space of international aid, generalising lessons learned in the scope of conditional giving.

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REFERENCES

[1] 2016. *Public trust and confidence in charities.* Technical Report. Populus.
[2] 2016. *UK GIVING 2015.* Technical Report. Charities Aid Foundation.
[3] 2017. *Data Protection, Privacy and Security for Humanitarian & Development Programs.* Technical Report. World Vision.
[4] 2017. *"White Paper Etherisc".* Retrieved August 15, 2020 from https://www.etherisc.com/whitepaper
[5] 2018. *Regulation of Cryptocurrency Around the World.* Technical Report. The Law Library of Congress, Global Legal Research Center. https://www.loc.gov/law/help/cryptocurrency/cryptocurrency-world-survey.pdf
[6] 2019. *UK GIVING 2019.* Technical Report. Charities Aid Foundation.
[7] 2020. "BitGive Foundation - 1st Bitcoin and Blockchain Nonprofit". Retrieved 17th July 2020 from https://www.bitgivefoundation.org/
[8] 2020. "Disberse: The future of aid finance". Retrieved August 15, 2020 from https://disberse.com/
[9] 2020. *"Giftcoin ICO cancelled".* Retrieved August 15, 2020 from https://icodrops.com/giftcoin/
[10] 2020. *"GrantHero: A decentralized non-profit organization (GitHub)".* Retrieved August 15, 2020 from https://github.com/granthero
[11] 2020. *"Helperbit: the most innovative way to fundraise".* Retrieved August 15, 2020 from https://app.helperbit.com
[12] 2020. *"PromiseGiving: Charitable Giving With Impact Guaranteed".* Retrieved August 15, 2020 from https://www.promisegiving.com/
[13] 2020. *"StartSomeGood: crowdfunding for non-profits, social entrepreneurs and changemakers".* Retrieved August 15, 2020 from https://startsomegood.com

[14] AidCoin. 2018. *AidCoin Whitepaper V0.4*. Retrieved August 15, 2020 from https://www.aidcoin.com/assets/documents/whitepaper.pdf?v=1.1.0

[15] V Babich and G Hilary. 2018. *What operations management researchers should know about blockchain technology.* Technical Report. Georgetown Working Paper.

[16] René Bekkers and Pamala Wiepking. 2011. A Literature Review of Empirical Studies of Philanthropy: Eight Mechanisms That Drive Charitable Giving. *Nonprofit and Voluntary Sector Quarterly* 40, 5 (2011), 924–973. https://doi.org/10.1177/0899764010380927 arXiv:https://doi.org/10.1177/0899764010380927

[17] Ardion Beldad, Menno De Jong, and Michaël Steehouder. 2010. How shall I trust the faceless and the intangible? A literature review on the antecedents of online trust. *Computers in human behavior* 26, 5 (2010), 857–869.

[18] Vitalik Buterin et al. 2014. A next-generation smart contract and decentralized application platform. *white paper* (2014).

[19] Rhett Butler, Thome Lay, Ken Creager, Paul Earl, Karen Fischer, Jim Gaherty, Gabi Laske, Bill Leith, Jeff Park, Mike Ritzwolle, et al. 2004. The Global Seismographic Network surpasses its design goal. *Eos, Transactions American Geophysical Union* 85, 23 (2004), 225–229.

[20] Weili Chen, Jun Wu, Zibin Zheng, Chuan Chen, and Yuren Zhou. 2019. Market manipulation of bitcoin: evidence from mining the Mt. Gox transaction network. In *IEEE INFOCOM 2019-IEEE Conference on Computer Communications*. IEEE, 964–972.

[21] Andrea Christie. 2020. Can Distributed Ledger Technologies Promote Trust for Charities? A Literature Review. *Frontiers in Blockchain* 3 (2020), 31. https://doi.org/10.3389/fbloc.2020.00031

[22] Nicolas Christin. 2013. Traveling the Silk Road: A measurement analysis of a large anonymous online marketplace. In *Proceedings of the 22nd international conference on World Wide Web*. 213–224.

[23] Nazli Cila, Gabriele Ferri, Martijn de Waal, Inte Gloerich, and Tara Karpinski. 2020. The Blockchain and the Commons: Dilemmas in the Design of Local Platforms. In *Proceedings of the 2020 CHI Conference on Human Factors in Computing Systems* (Honolulu, HI, USA) *(CHI '20)*. Association for Computing Machinery, New York, NY, USA, 1–14. https://doi.org/10.1145/3313831.3376660

[24] Giulio Coppi and Larissa Fast. 2019. *Blockchain and distributed ledger technologies in the humanitarian sector.* Technical Report. HPG Commissioned Report.

[25] Rhodri Davies. 2015. *Giving Unchained: Philanthropy and the Blockchain.* Technical Report. Charities Aid Foundation.

[26] Rhodri Davies. 2017. *Losing the Middle but Keeping the Heart: Blockchain, DAOs and the future decentralisation of charity.* Technical Report. Charities Aid Foundation.

[27] Primavera De Filippi. 2016. The interplay between decentralization and privacy: the case of blockchain technologies. *Journal of Peer Production, Issue* 7 (2016).

[28] Tom De Groeve, L Vernaccini, and Alessandro Annunziato. 2006. Global disaster alert and coordination system. In *Proceedings of the 3rd International ISCRAM Conference, Eds. B. Van de Walle and M. Turoff,, Newark*. 1–10.

[29] Deloitte. 2019. Deloitte's 2019 global blockchain survey. (2019).

[30] Jacob Eberhardt and Stefan Tai. 2017. On or Off the Blockchain? Insights on Off-Chaining Computation and Data. In *Service-Oriented and Cloud Computing*, Flavio De Paoli, Stefan Schulte, and Einar Broch Johnsen (Eds.). Springer International Publishing, Cham, 3–15.

[31] Steve Ellis, Ari Juels, and Sergey Nazarov. 2017. "ChainLink - A Decentralized Oracle Network". (4 September 2017). https://link.smartcontract.com/whitepaper

[32] Chris Elsden, Arthi Manohar, Jo Briggs, Mike Harding, Chris Speed, and John Vines. 2018. Making Sense of Blockchain Applications: A Typology for HCI. In *In Proceedings with CHI 2018*.

[33] Chris Elsden and Ludwig Trotter. 2019. *"Oxfam Australia Fieldwork Visit and Report"*. Technical Report. University of Edinburgh, Lancaster University, Oxfam Australia.

[34] Chris Elsden, Ludwig Trotter, Mike Harding, Nigel Davies, Chris Speed, and John Vines. 2019. Programmable Donations: Exploring Escrow-based Conditional Giving. In *Proceedings of the 2019 CHI Conference on Human Factors in Computing Systems*. 1–13.

[35] Chris Elsden, Ludwig Trotter, John Vines, and Chris Speed. 2019. Darkening Programmable Donations. (2019).

[36] Chris Elsden, John Vines, Anne Spaa, Kate Symons, and Chris Speed. 2018. Searching for an OxChain: CoDesigning Blockchain Applications for Charitable Giving. In *HCI for Blockchain: A CHI 2018 workshop on Studying, Critiquing, Designing and Envisioning Distributed Ledger Technologies*.

[37] Marcus Foth. 2017. The Promise of Blockchain Technology for Interaction Design. In *Proceedings of the 29th Australian Conference on Computer-Human Interaction* (Brisbane, Queensland, Australia) *(OZCHI '17)*. Association for Computing Machinery, New York, NY, USA, 513–517. https://doi.org/10.1145/3152771.3156168

[38] Neil Gandal, JT Hamrick, Tyler Moore, and Tali Oberman. 2018. Price manipulation in the Bitcoin ecosystem. *Journal of Monetary Economics* 95 (2018), 86 – 96. https://doi.org/10.1016/j.jmoneco.2017.12.004

[39] Oxfam GB. 2020. *Charity Gift Cards Oxfam Unwrapped*. Retrieved August 15, 2020 from https://www.oxfam.org.uk/shop/oxfam-unwrapped

[40] Oxfam GB. 2020. *Oxfam unwrapped: Frequently asked questions*. Retrieved August 15, 2020 from https://www.oxfam.org.uk/shop/help/unwrapped

[41] GoFoundMe. 2020. . Retrieved August 15, 2020 from https://www.gofundme.com/

[42] Joshua Hallwright and Elsa Carnaby. 2019. Complexities of Implementation: Oxfam Australia's Experience in Piloting Blockchain. *Frontiers in Blockchain* 2 (2019), 10. https://doi.org/10.3389/fbloc.2019.00010

[43] AXA Insurance. 2020. *Axa goes blockchain with fizzy*. Retrieved August 15, 2020 from https://www.axa.com/en/magazine/axa-goes-blockchain-with-fizzy

[44] Sue Wixley James Noble, Russell Hargrave. 2015. *Having their say: what the public likes and dislikes about charities.* Technical Report. New Philanthropy Capital.

[45] PROVABLE THINGS LIMITED. 2020. *"The Provable blockchain oracle for modern DApps ".* https://provable.xyz

[46] Matthew Marshall, David S. Kirk, and John Vines. 2016. Accountable: Exploring the Inadequacies of Transparent Financial Practice in the Non-Profit Sector. In *Proceedings of the 2016 CHI Conference on Human Factors in Computing Systems* (San Jose, California, USA) *(CHI '16)*. Association for Computing Machinery, New York, NY, USA, 1620–1631. https://doi.org/10.1145/2858036.2858301

[47] Matthew Marshall, John Vines, Pete Wright, David S. Kirk, Toby Lowe, and Rob Wilson. 2018. Accountability Work: Examining the Values, Technologies and Work Practices That Facilitate Transparency in Charities. In *Proceedings of the 2018 CHI Conference on Human Factors in Computing Systems* (Montreal QC, Canada) *(CHI '18)*. Association for Computing Machinery, New York, NY, USA, 1–12. https://doi.org/10.1145/3173574.3173849

[48] Finck Michele. 2018. *Blockchain Regulation and Governance in Europe.* Cambridge University Press. https://doi.org/10.1017/9781108609708

[49] Brenda M Michelson. 2006. Event-driven architecture overview. *Patricia Seybold Group* 2, 12 (2006), 10–1571.

[50] M. Möser, R. Böhme, and D. Breuker. 2013. An inquiry into money laundering tools in the Bitcoin ecosystem. In *2013 APWG eCrime Researchers Summit*. 1–14.

[51] Ivica Nikolić, Aashish Kolluri, Ilya Sergey, Prateek Saxena, and Aquinas Hobor. 2018. Finding the greedy, prodigal, and suicidal contracts at scale. In *Proceedings of the 34th Annual Computer Security Applications Conference.* 653–663.

[52] S. Pongnumkul, C. Siripanpornchana, and S. Thajchayapong. 2017. Performance Analysis of Private Blockchain Platforms in Varying Workloads. In *2017 26th International Conference on Computer Communication and Networks (ICCCN)*. 1–6.

[53] Jakub Wojciechowski Raphaël Mazet. 2017. Alice white paper. online. Retrieved August 15, 2020 from https://github.com/alice-si/whitepaper

[54] "The Engine Room". "2016". *"Hand-Book Of The Modern Development Specialist".*

[55] Johannes Sedlmeir, Hans Ulrich Buhl, Gilbert Fridgen, and Robert Keller. 2020. The energy consumption of blockchain technology: beyond myth. *Business & Information Systems Engineering* (2020), 1–10.

[56] Savva Shanaev, Arina Shuraeva, Mikhail Vasenin, and Maksim Kuznetsov. 2019. Cryptocurrency value and 51% attacks: evidence from event studies. *The Journal of Alternative Investments* 22, 3 (2019), 65–77.

[57] Sebastian Sinclair. "2020". *Ethereum Classic Suffers Second 51% Attack in a Week.* Retrieved 19 Aug 2020 from https://www.coindesk.com/ethereum-classic-suffers-second-51-attack-in-a-week

[58] Henrik S Sternberg, Erik Hofmann, and Dominik Roeck. 2020. The Struggle is Real: Insights from a Supply Chain Blockchain Case. *Journal of Business Logistics* (2020).

[59] Lawrence J Trautman. 2014. Virtual currencies; Bitcoin & what now after Liberty Reserve, Silk Road, and Mt. Gox? *Richmond Journal of Law and Technology* 20, 4 (2014).

[60] Fabian Vogelsteller and Vitalik Buterin. "2015". *"EIP 20: ERC-20 Token Standard".* Retrieved 15th June 2020 from https://eips.ethereum.org/EIPS/eip-20

[61] Gavin Wood. 2014. Ethereum: A secure decentralised generalised transaction ledger. *Ethereum project yellow paper* 151 (2014), 1–32.

[62] Q. Zhou, H. Huang, Z. Zheng, and J. Bian. 2020. Solutions to Scalability of Blockchain: A Survey. *IEEE Access* 8 (2020), 16440–16455.